Biodiversity Conservation Priorities

In the Three Regions of the

Landscape Development Interventions Program

(Part I)

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Forward

The Montadia to Onibe Corridor north of the *route nationale* in the Moramanga Region is one of the largest remaining intact blocks of rainforest in Madagascar. The conservation of this corridor has been targeted as a conservation objective by the government of Madagascar, by USAID and by the LDI Program. The same area as it is depicted on the undated (ca. 1995), recently published CI/CNRE/MEF/FTM National Ecological Forest Inventory Map (IEFN) represents the corridor as interpreted from 1950's aerial photography. The map shows that most of the southern half of the corridor was then 25 – 30 km wider then as its present day width of 20-30 km. Most of this loss probably did not occur until after 1975 when major natural resource policy changes were made throughout Madagascar by the national government. This represents an average loss of over 1 km/yr. from the east side. The loss continues today, but at an unquantified rate.

Since 1975, the population of Madagascar has about doubled and economic conditions have declined drastically throughout the country. The farmers on the east side of the corridor today make their living primarily from ecologically unsustainable, slash-and-burn *tavy* agriculture. *Tavy* depends on the clearing of more and more rainforest to make up for declining yields as soils are depleted. These farmers today are more impoverished, less literate and have less access to credit, inputs, markets, and government services than the farmers of 23 years ago. They are more dependent than ever on their unsustainable *tavy.*

Over the past 30 years, this same area has had more research done on alternatives to *tavy* agriculture than any other part of the country. Yet one has not yet even begun to reverse the trends of the past 23 years. Even the relatively robust 20 to 30 km wide remaining corridor suddenly looks very frail in perspective when one ponders the challenges. One must not only reverse the trends of 23 years but also achieve sustainability in the ecological, economic and social senses of the term…. And one must hopefully achieve this before the rainforest corridor and those life forms that live there disappear entirely and forever.

Biodiversity Conservation Priorities in the Three Regions Of the Landscape Development Interventions Program

1. Context

The LDI Program contributes to Strategic Objective #3 of the USAID Mission's Country Strategic Plan: *"Conserve biologically diverse ecosystems in Priority Conservation Zones (PCZs) of Madagascar through improved natural resources management."* To achieve this, LDI will intervene primarily in the areas of agricultural intensification and in enterprise promotion. One of the key challenges of the six-month planning process are the strategic choices of key geographic areas and of the specific types of interventions through which the project can have the greatest impact on the conservation of priority ecosystems.

The definition of conservation priorities for the ecosystems in each of the three LDI regions is a key factor for the choice of the Strategic Intervention Zones (SIZs). The SIZs are where LDI's agricultural intensification efforts will be concentrated. Strategic linkages to conservation priorities will also be a criteria used to decide whether or not to respond favorably to requests for assistance for enterprise promotion in the three regions. A review and update of conservation priorities in the three regions is therefore a key element of the planning process. The Eco-Regional Planner took the lead in this review. This paper presents a synthesis of this review with specific recommendations for conservation priorities in the three LDI regions.

2. Methodology

2.1. Overview The most important reference documents on biodiversity conservation priorities in Madagascar are those that came out of the Scientific Priority-Setting Workshop held in Antananarivo in April 1995. A quick review of these documents just after the launch of the project raised many questions about the adequacy of these documents for the definition of regional priorities. This eventually led to the decision to undertake a completely new review of regional biodiversity conservation priorities. Working in collaboration with Malagasy and expatriat specialists, priority-ranking methodologies developed for national biodiversity strategy and action plans (BSAP) were modified to develop a highly innovative approach to regional priority setting in LDI's three regions. The main elements of these methodologies that were developed and used for a better definition of regional priorities for the three regions where LDI will work are the following:

- Determination as to whether AGERAS had already defined regional priorities for biodiversity conservation beyond what was done in the 1995 Priorities Workshop.
- Identification and procurement of key reference documents;
- Interviews with six of the more knowledgeable researchers/resource people the

most familiar with the biodiversity of Madagascar, to get their input on:
  - The strengths and weaknesses of the 1995 workshop;
  - New research results that were not available or not included in the 1995 review;
  - Their input on criteria for the definition of biodiversity priorities;
  - Their specific recommendations on conservation priorities for each region with their justification for their choices.
- An assessment of the methodologies and results of the 1995 workshop in view of their usefulness for LDI regional priorities;
- A definition of ecosystems types for the three regions;
- Review of criteria for biodiversity priority-setting and their adaptation for regional priority-setting in Madagascar;
- Definition of priorities at the ecosystem level;
- Development of a methodology for the definition of priorities within each region;
- Preparation of a written summary of proposed conservation priorities for each of the three LDI regions. These are accompanied by maps prepared by LDI subcontractor PACT.

2.2. AGERAS' Role in Regional Biodiversity Conservation Priority Setting

AGERAS is actively leading a decentralized planning process in the two LDI regions of Fianarantsoa and Moramanga. In both areas, their geographic focus is on sections of the eastern rainforest escarpment corridors between major protected areas. This is the Montadia to Onibe River Corridor in the Moramanga region and the Andringitra to Ranomafana corridor in the Fianarantsoa region. These are the same two corridors that have been suggested as conservation priorities for LDI. However, LDI's geographic regions covered during the planning process are much larger than the two corridors where AGERAS is focusing their efforts.

In late October – early November, LDI regional staff and the Eco-Regional Planner visited with the AGERAS teams in Moramanga and Fianarantsoa to learn whether AGERAS had already undertaken a review of regional priorities biodiversity conservation in these two areas. It was found that AGERAS has not undertaken a review or update of conservation priorities in the larger geographic regions that LDI is assessing. At Moramanga, AGERAS plans to make use of the results of a rapid biodiversity assessment (RBA) being done on the Montadia to Onibe Corridor under the lead of Conservation International (This has since begun in November) to better define priorities within the corridor. Preliminary results may become available early in 1999. In Fianarantsoa Region, no biodiversity assessments have been done or are underway in the Andringitra to Ranomafana corridor.

After determining that regional biodiversity conservation priorities had not already been defined, LDI decided they needed to take the lead in doing this in all three areas, using the 1995 Priorities Workshop results as a base.

2.3. Key Reference Documents

The most important reference documents used for the review are the following:

- "Priorities for Biodiversity Conservation in Madagascar" (Primate Report – Special Issue 48-1), June 1997. This presents the principal findings of the 1995 Priorities Workshop including methodologies, criteria and results by thematic and by geographic working groups.
- The 1:2000,000 scale map by the same name as the above report;
- The 1997 forest cover map of Madagascar entitled: *Inventaire Ecologique Forestier National* (We shall refer to it as the IEFN Map). This map is by far the best map available that covers all of Madagascar and that shows the areal extent of the major ecosystems. It was prepared by manual interpretation of LANDSAT 5 TM imagery recorded between 1990 and 1994. It is the single most important planning document for the LDI planning process. This map was used in both its hardcopy and digital forms;
- The digitized form of the 1:500,000 scale topographic map set of Madagascar. This database is called the *BD 500*.

2.4. Resource People Interviewed and Key Findings

The key resource people interviewed are the following:

- Dr. Faramalala, Director of ANGAP's *Département d'Information et de la Valorisation de la Biodiversité* (DIVB);
- Dr. Ron Nussbaum, Professor at the University of Michigan at Ann Arbor, Herpetologist;
- Dr. Chris Raxworthy, Professor at the University of Kansas. Herpetologist;
- Dr. Steve Goodman of the Field Museum of Natural History in Chicago. Specialist in small mammals;
- Dr. Frank Hawkins of Birdlife International. Ornithologist, trained in conservation biology and technical advisor to Projet ZICOMA.
- Dr. Martin Nicoll, WWF advisor to ANGAP for southern Madagascar and co-author of a book on the protected areas of Madagascar.

One of the main impressions obtained from the interviews with specialists on the biodiversity of Madagascar has been to reconfirm, once again, just how incredibly fragile is the ecology of most of Madagascar's natural ecosystems. It seems that Madagascar's plants and animals have never evolved the qualities that are needed to survive the types of disturbances introduced with the arrival of man on the island. This is especially true of man's use of fire and of clearing for agriculture. Fire and/or agricultural clearing typically lead to the conversion of Madagascar's exceptionally biodiverse forests into exceptionally un-diverse and unproductive *tanety* grasslands.

Researchers seem to be in quite general agreement that most Malagasy species of fauna and flora are exceptionally incapable of dispersing across even quite narrow gaps between fragments, especially where forest fragments are separated by tanety grasslands. A 100 to 200 meter gap between fragments probably serves as an effective break for most species of reptiles and amphibians. In most parts of the world, birds are typically amongst the species best adapted for dispersing between fragments. Malagasy birds reputedly will rarely fly between fragments over even short distances when the fragments are within sight of each other. The Malagasy native flora has an exceptionally weak capacity to recolonize deforested areas. Lack of dispersal mechanisms seems to be an especially important cause.

2.5. Assessment of the Usefulness of the 1995 Priorities Workshop for LDI's Needs

As the 1995 Priorities Workshop was the most important attempt to date to define biodiversity conservation priorities, it is critical to understand what was done and what the strengths and weaknesses of the Workshop results are.

2.5.1. Strengths

- **Basic reference for BD priorities.** The 1995 workshop was by far the most serious attempt to define national biodiversity priorities in a systematic fashion. The workshop results are considered the basic reference document on this subject for Madagascar;
- **Participation and consensus.** Over 100 scientists were involved in the workshop and in the preparation of the databases and background documents prior to the workshop. The workshop was conducted in a participatory fashion and priorities generally represent the consensus of the participants.

2.5.2. Weaknesses

- **Lack of systematic approach** Databases were prepared in advance for each of the working groups – mammals, birds, reptiles and amphibians, invertebrates, plants, aquatic ecosystems. Distribution maps for plants and animals were printed from the databases, but they were of much less use than hoped for. The reasons given were summarized in the June 1997 report on the Workshop as follows:
  1. *"Surveys did not cover the island systematically, neither in terms of geographical distribution, nor in quality and intensity, but tended to be concentrated in some (mainly protected areas).*
  2. *It was unclear to what extent gaps in the distributional records represented areas where the species in question is not present, whether there was no survey, or whether there was a survey which failed to report the species.*
  3. *Many of the geographic references for surveys are inaccurate;*

4. *Species identification was unclear;*
5. *There were errors in data compilation, entry and processing.*
6. *The results of recent unpublished surveys indicated that, with the possible exception of lemurs and birds, the published database represents a misleading picture of the true distribution of many species."*

All this makes it very difficult to impossible to compare two of the most widely recognized criteria for biodiversity conservation priority ranking, (species diversity and endemism) between sites and between ecosystems in a systematic way. As a result, the databases were not used directly in the preparation of the integrated priorities map of biological importance. Instead this map represents the consensus reached by the three integrated regional groups that were formed. Each regional group was composed of representatives from the different thematic groups. The priorities represent the subjective professional judgment of the members of these working groups.

- The '95 Priorities are done by site, not by ecosystem or habitat type. The sites are discontinuous. They do not correspond to the limits of the vegetation/ecosystem types on the maps that were available at the time. They do not come close to covering all of the forested areas, even when the "Unknown" site category is included. For most of the thematic group priority maps, half or more of the "primary" forest ecosystems are neither given a priority nor even marked as unknown.
- The main vegetation map used by the workshop had severe limitations. Although just published, it was made primarily from old 1970's Landsat MSS images. However, no satellite imagery at all was available for large parts of the eastern rainforest. These portions of the map were taken from another map done from the 1950's aerial photographs. Large areas of Dry Forest in the Mahajanga Region do not appear on the map used by the Workshop.
- The results of the workshop were not made available to many scientists and conservationists in Madagascar for the 3.5 years following the workshop, the time during which they could have been the most useful. The delays and limited availability have also lead to a limited ability of field biologists to test and evaluate the Workshop results. Some of the researchers interviewed had still never seen the published workshop results, other than the Priorities maps.
- Several of the priorities on the integrated map of biological priorities do not appear to have any logical basis in relation to the priorities identified by the different thematic working groups. For example, the coastal area northeast of Mahajanga that is classified as being of Exceptional Priority was not classified as having any unusual level of importance on any of the thematic groups priorities maps. Other examples are also found in LDI's three regions.
- Some of the place names used to describe priority sites do not correspond to the geographic areas indicated on the Priorities Map.

In conclusion, although the '95 Priorities Workshop is the best reference available for biodiversity conservation priorities for Madagascar as a whole, it has severe limitations.

By itself, it provides a very unsatisfactory definition of priorities for the three regions in which LDI is working. The weaknesses of the '95 Priorities Workshop results combined with the opportunities presented by the new IEFN vegetation/ecosystem map were both strong arguments for the need to take a new look at conservation priorities for LDI's three regions.

2.5.3. Major Recommendations from the Priorities Workshop

Four general recommendations from the workshop are of particular importance to our analysis of biodiversity priorities:

- **Fragmentation** threatens all forest ecosystems. Corridors connecting forest blocks and protected areas need to be maintained to permit the exchange of species and genes;
- **New boundary for lowland rainforest** The upper boundary of the typical Low Altitude Rainforest in now considered to extend only up to 500-600 meters. Lowland eastern rainforest is one of the most threatened of all Malagasy ecosystems and is in great need of protection/conservation;
- **Key priorities outside of PAs.** Many areas of outstanding biological importance occur outside of protected areas. The protected areas system needs to be extended and biological research needs to include these little known but very important areas. (This is all part of the justification for the landscape ecology approach adopted by LDI.);
- **Littoral forests** in the east are highly threatened and in special need of protection.

2.6. Ecosystems in the Three LDI Regions

2.6.1. Classification System There is no clear, commonly accepted definition of an ecosystem. Likewise, there is no clear agreement on the differences in meaning between such terms as ecosystem, biogeographical zone, domaine, formation or habitat. We shall use the Convention on Biological Diversity's definition:

> *"'Ecosystem' means a dynamic complex of plant, animal and micro-organisms and their non-living environment interacting as a functional unit."*

Although the term habitat is often used in the same sense as ecosystem in Madagascar, habitat is more correctly used to describe the more specific environment where a given species of animal is commonly to be found. Habitat refers to more specific variations within an ecosystem that reflect local physical conditions, past disturbances or other factors.

There has been no major effort by biogeographers to develop an ecologically-based classification of Madagascar's ecosystems based on survey data. The 1995 workshop

largely avoided the issue of ecosystem classification, and based their priorities on subjectively defined sites. Each thematic group used different divisions based on the preferences of the membership of each group.

Humbert developed an ecosystem classification system in the latter part of the first half of this century. (He used the term "*domaine*" for his categories). It is probably the system most commonly used by researchers in Madagascar. Humbert's system is based primarily on his impressions of the major differences based on his field experience. Humbert's classification system was used for the 1997 *Inventaire Ecologique Forestier Nationale.* Humbert's system has the major advantage of being the system used on the only recent map of Madagascar's ecosystems/vegetation cover.

The one clear exception to the general agreement with the IEFN classification is the altitudinal break between Low Altitude and Mid-Altitude Rainforest. The 1995 Priorities Workshop achieved quite a strong consensus that the break between these two ecosystems occurs at 500-600 meters as opposed to the 800 meter break on the IEFN Map. All but one (Nussbaum) of the researchers interviewed agreed with this recommendation. For this reason, the GIS unit of LDI sub-contractor PACT was asked to redo the limit between these two types at 550 meters.

LDI, AGERAS and USAID organized an Ecosystem Priorities meeting with key biodiversity researchers and conservationists on January 5, 1999. The participants were as follows:

Lynn McCoy	Team Leader, Results Package 2	USAID
Steve Goodman	Coordinator, ETP (Biologist)	WWF
RATSIMBAZAFY Remi	Consultant (Biologist)	WWF
RASELIMANANA Achille	Biodiversity Program (Biologist)	WWF
Jean-Michel Dufils	Technical Advisor	PACT
RAKOTOARISOA Soava	Research and Biodiversity (Biol)	ONE
ANDRIANTSOANINA Benja	Forest Manager	GELOSE/ONE
ANDRIATSARAFARA Solofo	Scientific Support	ONE
RAMIARISON Claudine	Biodiversity Unit	ONE
Jutta Schmid	RAP Team Leader (Biologist)	CI
ZO Lalaina	Monitoring & Evaluation (Biol)	CI
Sahondra Radilofe	DSI (Biologist)	CIMAD
Jean Chrys RAKOTOARY	DGA	ONE
Lisa Gaylord	Environmental Program Coord.	USAID

The first order of business of this Ecosystem Priorities group was to review and revise the ecosystem classification. They first discussed a controversial change to Humbert's system recommended by Hawkins. Hawkins recommends that the Mid-Altitude Rainforest be subdivided into a Mid-Altitude Rainforest and a Low Montane Forest type with the break at 1200 meters. The Ecosystem Priorities group rejected this proposal at

this point. Perhaps future systematic biodiversity surveys can better test Hawkin's hypothesis. The Ecosystem Priorities group did recommend another modification to the altitude limit to the name and upper altitude limit for Humbert's Mid Altitude ecosystem/domaine. This has been renamed Montane Rainforest with an upper limit of 1550 meters.

The IEFN Map has a woodlands category in, and south of, Isalo National Park in extreme western Fianarantsoa Region. Hawkins has argued that this is primarily Tapia Woodlands dominated by one of the few fire resistant indigenous tree species, the tapia tree. The Ecosystem Priorities Group argued that the tapia ecosystem is a badly degraded ecosystem, and should not be included as a "primary" ecosystem. The author believes that the tapia type is actually a savanna type (savannas are characterized by a continuous grass cover and a less than continuous tree crown cover) and agrees that it should not be considered a "primary" ecosystem. The author recommends, however, that it be more accurately determined just what the IEFN Woodlands ecosystem type actually corresponds to. Is it a true woodlands type with a near continuous tree canopy and a discontinuous grass/herbaceous cover? Is it different from the Dry Forest type? Is it a tapia savanna? Is it a mixture of ecosystem types?

The main Humbert/IEFN ecosystem classes that occur in the three LDI regions as modified by the '95 Priorities Workshop and the January 5 Ecosystem Priorities group are the following:

Zonal ecosystems:

Low-Altitude Rainforest (0 -- 550 m.)	Mor & Fia
Montane Rainforest (800 – 1550 m)	Mor, Fia & Mah
High Montane Forest (1800+ m	Mor, Fia & Mah
Dry Forest	Mah (&Fia)
Littoral Forests	Mor & Fia
Woodlands? (Isalo)	Fia

Azonal Formations (occur only under special, local environmental conditions):

Mangroves	Mah
Marshes	Mor, Fia & Mah
Fresh Water Lakes	Mor, Mah
Lagoons	?
Rivers	Mor, Fia & Mah

2.6.2. General Description of Each Ecosystem

The Low Altitude Rainforest was once one of the most important in Madagascar covering most of the wide swath of land between the eastern escarpment and the Indian Ocean. This evergreen, broadleaf, closed-canopy forest is now one of the ecosystems most reduced in aerial extent. Only on Masoala Peninsula are their large blocks of this ecosystem still intact. The Low Altitude Rainforest is characterized by high species

richness and high levels of endemism. Most of this ecosystem is not found on east-facing escarpments. Consequently, it tends to be much drier, especially in the dry season, than the Mid-Altitude Rainforest which do occur primarily along the eastern escarpment. It is, therefore, more susceptible to fire.

The Montane Rainforest was also originally one of the major ecosystems of Madagascar. The Montane Rainforest (called Mid-Altitude Rainforest on the IEFN Map) is also an evergreen, broadleaf, closed canopy forest. Unlike the Low Altitude Rainforest, large blocks of this ecosystem still exist, although most of them are under severe pressure, especially from slash-and-burn *tavy* agriculture. Most of the remaining rainforests south of Masoala are of this type, and most occur within the now-broken north-south corridor along the escarpments. Orographic uplift along the escarpment creates very moist "cloud forest" conditions, even during much of the dry season. These moist conditions and the typically very steep relief have helped to protect this ecosystem from fire, agriculture and forest exploitation. The Montane Rainforest is similar to the Low-Altitude Rainforest in its high levels of species richness and endemism. Species composition within the corridor is far from uniform. For example, there is a continuing turnover, or change, in the species composition of reptiles and amphibians as one goes from north to south.

High Montane Forests and related habitats are found over 1550 meters elevation. These forests tend to be considerably more stunted than the Mid-Altitude Rainforests…. They are sclerophylous – displaying a variety of adaptations to moisture stress such as small, leathery or waxy leaves. Endemism is high and species richness is moderate. Elevation, slope, aspect, rainfall, soil depth, and other factors lead to considerable variety in the montane habitats. The High Montane ecosystem is one of the least threatened in Madagascar because of its relatively severe climate, its unsuitability for agriculture and its difficult access. The High Montane ecosystem still covers much of its original range.

Dry Forest The Dry Forest once covered larger areas than any other ecosystem in Madagascar. The remaining areas of Dry Forest represent only several per cent of the original geographic coverage of this type. The Dry Forest has lower species richness than the eastern rainforests, but is characterized by high levels of endemism. With an eight month dry season, the Dry Forest still has a closed canopy, but is composed of a variable mix of evergreen and deciduous tree species.

Littoral Forests are closed canopy forests found in both the Moramanga and Fianarantsoa regions. They tend to be fairly small fragments aligned parallel to the coast occurring on a variety of soils that run from pure sand to lateritic soils. The species diversity tends to be exceptionally low compared to that of the Low-Altitude Rainforest but varies considerably between sites. Bird diversity is particularly low. Endemism is high. Most of the Littoral Forests have already been quite severely degraded. Lying right on the coast, Littoral Forests take the full brunt of cyclones. Cyclones sometimes strip all the leaves from the trees in the littoral forests, leaving the arboreal fauna with no place to hide.

The Woodlands ecosystem occurs only in the extreme western edge of the Fianarantsoa Region. The Woodlands are found both in the Isalo National Park and south of the park. As already discussed, opinions vary considerably as to what this IEFN type actually consists. How much of it is actually degraded tapia savanna and how much represents one or more "primary" ecosystem types? In more protected areas with natural firebreaks, islands of closed canopy forests of higher diversity are found. This includes Dry Forest and even relict stands of rainforest in narrow canyons.

Mangroves The Mangrove ecosystem is the most distinctive, easily recognizable of the forest ecosystems Madagascar. Mangroves are found in intertidal bays, estuaries and relatively protected coastal sites, primarily on the west coast of Madagascar. They have low levels of species richness and endemism. Most of the original mangrove areas are still relatively intact. They play a highly important ecosystem function as essential sites for the reproduction of many species of marine life, including many species of high commercial importance.

Marshes are one of the most threatened ecosystems in Madagascar because most have been converted to rice paddies. This is linked to the very high cultural and economic value placed on rice. Eastern marshes are also being heavily invaded by the Australian exotic small tree, the "niaouli" (probably a species of Melaleuca). Very little of the remaining marshes enjoy any type of protected area status. Marshes tend to have moderate levels of endemism and species richness.

Lakes have moderate levels of species richness and endemism. Their areal extent has not been seriously reduced, but they suffer a variety of pressures including high levels of sedimentation, overfishing, loss of adjoining marshes critical for reproduction sites, deforestation of their watersheds, etc.

Lagoons are similar to lakes, but occur in intertidal areas and have brackish water.

Rivers have relatively low levels of species richness and moderate levels of endemism. The hydrological equilibrium of many, if not most, of Madagascar's rivers has been severely disturbed by deforestation of their watersheds. Some rivers have such high levels of sediment loads that no insects or higher animals are found in them. The ecological health of river ecosystems is inseparable from that of their watersheds.

2.7. Ecosystem Priorities at the National Level

2.7.1. Criteria for Defining Conservation Priorities by Ecosystem

General. Biodiversity covers the diversity of life at the ecosystem, species and the genetic levels. If one can conserve large blocks of undegraded ecosystems with a broad diversity of habitats, then one can generally also

conserve a large part of the species that make up that ecosystem along with much of the genetic diversity of those species. Attempts to conserve species without conserving the habitat and ecosystems where they live are generally unsuccessful.

Two broad levels of priority setting are recognized as appropriate for the three regions where LDI will work. The first is at the ecosystem level. This seeks to define the relative conservation priorities for the different ecosystems that occur within LDI's three regions. The second level is that of the individual blocks of remaining natural areas in each region. Each block may be composed of one or more ecoystem types. Each block varies in size, shape, and in its degree of degradation. One of the key challenges facing LDI has been the development of methodologies to best assign relative conservation priorities amongst these different blocks of natural areas.

Criteria have been developed for defining conservation priorities based on their biological importance. This has been done first, at the ecosystem level, and, secondly, at the level of individual blocks of natural areas in each region. The main reference used in developing these criteria is the Guide for the Preparation of National Biodiversity Strategies and Actions Plans prepared by UNDP for the May 1998 Conference of the Parties for the Convention on Biological Diversity. The Guide presents a collective set of criteria that were developed for ranking the relative priorities at both the general ecosystem level and at the level of individual blocks or geographical units of natural areas. This collective set was separated into two sets of criteria – one for the ecosystem level and the second for the level of individual blocks. At the January 5 meeting of the Ecosystem Priorities group, the list of criteria for priority-setting at the ecosystem level were adopted without modification.

It is important to recognize that the criteria developed are based on biological importance and are independent from the level of current man-caused threats and pressures on the ecosystems. Biological importance should change little over time. Threats and pressures change continually. Furthermore, most aspects of threats and their direct and indirect causes are best analyzed locally in each region.

LDI has benefited from the exceptional concentration of biodiversity researchers and conservation professionals in Madagascar to adapt and improve on the criteria from the Guide. In adapting the criteria and in developing the methodologies for applying them, LDI has also taken advantage of a set of circumstances that are very exceptional for a country like Madagascar:

- The recently completed, high quality IEFN map in its hardcopy and digital form;
- The recently completed digitization of the 1:500,000 scale topographic map base of the country (*Le BD500*.)
- The GIS capabilities of the Antananarivo office of Chemonics' subcontractor PACT;

Criteria for Ranking by Ecosystem follow. Priority is accorded to ecosystems:

1. With the highest rate of species endemism;

   The most striking aspect of the biodiversity of Madagascar is its exceptional level of endemism of most of its ecosystem types. Overall endemism rates of 75-80% lead to widespread recognition (circa 1987) of Madagascar as the World's number one priority for biodiversity conservation. Endemism is widely recognized as a key criteria for priority setting.
2. With the greatest species richness (the highest species diversity);

   Species richness is again a very widely accepted criteria for priority setting.
3. Whose present day geographic extent is the most reduced compared to their original geographic coverage.

   The Low-Altitude Rainforest and the Dry Forest in Madagascar are classic examples of ecosystems that once covered vast areas and which are now largely reduced to scattered fragments of varying sizes.
4. That play key ecological functions

   Mangrove ecosystems serve as estuaries essential for the reproduction of many forms of marine life. Rainforests on the steep eastern escarpment play a key watershed/hydrological role in moderating flooding and in minimizing soil erosion);
5. That are the least degraded

   Badly degraded and secondary forests in Madagascar have exceptionally low biodiversity value compared to similar types in most countries. Most of Madagascar's fauna and flora never evolved the ability to adapt to the types of disturbances introduced with the arrival of man on the island. Malagasy ecosystem have an exceptionally weak ability to recover following their destruction or their disturbance by man.

2.7.2. Resulting Priorities by Ecosystem

The above criteria were applied systematically to the ecosystems found in LDI's three regions. Criteria 5 (degradation) can be applied to the IEFN Map simply by eliminating all forest types that are classified as degraded or secondary. The other criteria are considered to apply to the non-degraded ecosystems.

Three-tiered ranking for each criteria Three levels of importance were defined for the application of each Criteria 1 to 4 to each ecosystem as follows:

3 High
2 Medium
1 Low

To be explicit, the High ranking is given to ecosystems 1. that have the highest endemism; 2. that have the greatest species richness; 3. that are the most reduced in relation to their original geographic extent; and 4. that play the most key ecological functions.

To our knowledge, no one has ever done systematic surveys of the ecosystems that occur in LDI's three regions in a way that would permit on objective ranking of endemism and species richness by ecosystem. However, these factors are well enough known that we feel these ecosystems can be ranked subjectively by knowledgeable scientists fairly accurately using our three-tier High to Low ranking system. Future systematic surveys could allow a more objectively quantifiable ranking. In a similar fashion, the third criteria is quite easy to apply subjectively. Once again, this would be easy to quantify if researchers can agree on the probable original geographic coverage of these ecosystems. Criteria 4 on key ecological function is probably the most difficult to achieve a clear consensus.

Table 1 presents the January 5, 1999 ranking of each ecosystem for each criteria as done by the Ecosystem Priorities group.

Relative weighting of criteria

The relative weighting of the criteria needs to be established. It is proposed that Criteria 1 to 3 each carry equal weight. Criteria 4 is less directly a function of the biological importance per se of an ecosystem and more subjective in its application. A weighting of half of that of the first three criteria is proposed. The weighted total in Table 1 was calculated by multiplying the ranking for Criteria 4 by ½ and adding it to the full values for Criteria 1 to 3. The highest totals correspond to the highest biological importance, i.e., the highest priority for conservation at the ecosystem level.

Table 1 Conservation Priorities by Ecosystem

Criteria IEFN Ecosystem	End-emism 1	Sp. Rich. 2	% Re-maining 3	Ecol. Funct. 4	Total	Rank
Littoral Forest	2	1	1.17	1.8	5.97	#10
Low Altitude Rainforest	3	2.86	2.57	2.43	10.86	#1
Montane Rainforest	2.86	2.29	2.29	2.5	9.94	#3
High Montane Forest	2.86	2.14	1.57	2.71	9.28	#4
Woodlands	?	?	?	?	?	?
Dry forest	3	2	2.83	2.1	10.0	#2
Mangroves	1	1.67	1.25	3	6.92	#8
Marsh	1.75	1.75	2.75	3	9.25	#5
Lakes	1.8	1.6	1.6	3	7.8	#6
Rivers	1.3	1.6	1.25	3	7.16	#7
Lagoons	1	2	1	2	6	#9

Ranking :
3 : High
2 : Medium
1 : Low

2.8. Regional Priorities at the Block Level

2.8.1. Criteria for Defining Priorities by Block

In each region, the remaining natural areas consist of large to small blocks of varying size and shape and with varying composition of one to several ecosystem types. The following criteria were developed and amended by the Ecosystems Priorities group for the ranking of the conservation priority of each block.

Priority is accorded to blocks:

1. Of the largest size;

There is a growing consensus amongst conservation biologists both internationally and in Madagascar that it is critical to attempt to conserve the largest blocks possible of natural ecosystems. Blocks must be large enough to maintain viable populations of fauna and flora over time. Size is a criteria that is easy to apply using GIS capabilities.

Criteria 1 is based on a principle of biogeography that came out of research on island ecology. The essence of this well-established principle is that the species diversity that a given ecosystem is capable of supporting is a direct function of the physical size or areal extent of that ecosystem. If you take a 1000 has. block of rainforest and split it into two fragments of 500 has., then each block will begin to lose species even in the absence of any human pressures on the ecosystem. This loss will continue over quite a long period of time before reaching a new equilibrium. Other factors being equal, the smaller blocks are not capable of supporting the same level of diversity as the single large block.

This principle seems to operate on all scales, i.e., to hold for large areas and small fragments. Biodiversity loss from fragmentation is occurring all over the world. It is a process that is probably accelerating in Madagascar, especially as the eastern rainforest becomes increasingly fragmented. In Madagascar, fragmentation is commonly correlated with moderate to severe human pressures on the fragments resulting in even greater and more rapid loss of diversity than would occur from the fragmentation by itself.

Ecologists have not been very successful in predicting the level of diversity to expect for a given size of a given ecosystem, but there seems to be strong agreement that diversity decreases with decreasing size, and that the decreases are very significant.

Closely associated with the criteria of block size, is the idea of corridors that connect larger natural areas. Corridors serve the ecological function of allowing for exchange of species and genes between the connected areas maintaining them as one single block. The corridor itself contributes to the overall size of the

block(s). If the corridor is cut, the single block becomes two. If this happens, one must expect each remaining block to begin to lose part of its biodiversity. The IEFN Maps show many areas where corridors are threatened with being cut.

2. That include the widest range of ecosystems within the limits of the block

For zonal terrestrial ecosystems, the range of ecosystems found within a given block is closely associated with the altitudinal range found within the block. Most terrestrial ecosystems do not have sharply defined dividing lines between them. Most share a large percentage of their species of flora and fauna between them. Given a choice of conserving two blocks of equal size, one composed of a single ecosystem type and the second of two or more types, one should give priority to the conservation of the second. The second block will have higher biological diversity and a greater capability for a large part of its species to survive changes in weather and climate. This is a second criteria that is easy to apply using GIS analysis.

3. Of the lowest ratio of circumference to size;

This criteria is basically a pragmatic assessment of the feasibility of conserving a given block. Most of the pressures on natural areas occur along the circumference of the block – the zone of interface between the man-altered landscape and the natural area. The circumference should include the circumference of man-altered landscape inclusions within the block itself. The cost of effectively conserving a block can be considered to be in direct relationship to the circumference of the block. With limited resources, it should be more efficient to conserve compact blocks with a low ratio of circumference to size. This criteria, again, is relatively easy to apply with GIS capabilities.

4. That have the highest priority ecosystems contained within the block;

This refers to the ecosystem priority ranking from 2.7.2.

5. That are scientific "Hot Spots"

This may include sites identified in the "95 Priorities Workshop, or known sites with rare and endangered species, high primate density, sites important for migratory species, or similar scientific particularities.

2.8.2 Degraded and Secondary Ecosystem Types

An IEFN map unit is a circled block of an individual ecosystem or other cover type on the map. All of the map units or blocks of "primary" forest ecosystems types (shown in the brightest colors on the published maps) on the IEFN Maps are the principal objects of our priority ranking in each region. Most of the other cover types on the IEFN Maps are totally man-altered types that have very little interest for biodiversity conservation. These are not covered in our ranking of priorities. However, special consideration has been made of the degraded and secondary forest cover types.

Degraded and Secondary Forest Rainforests.

The IEFN maps have a degraded/secondary forest category for each of the two Low Altitude and Montane Rainforest ecosystems. These two types should be treated with skepticism and should be checked in the field. Actually, they probably represent fallow areas. In the experience of the author and of the researchers interviewed, savoka fallow that comes in after slash-and burn tavy agriculture, rarely has time to develop into secondary forest through plant succession. They are normally slashed-and burned again every few years. They are not degraded forests, because the forest was completely destroyed.

Selective logging and other pressures that do degrade the rainforests rarely have enough impact on the forest canopy to have much effect on the spectral response of the forest on the imagery used for preparing the IEFN Map. Researchers claim that partially degraded rainforests maintain most of their species as long as the canopy remains largely intact. The secondary/degraded rainforest categories are probably fallow agricultural land, however. As such, they will have little value for biodiversity conservation.

For the above reasons, blocks of the IEFN degraded/secondary categories for Low Altitude and Montane Rainforests should be eliminated from the priorities ranking in each region. The block ranking criteria should be applied to blocks of non-degraded rainforest types.

Degraded and Secondary Dry Forest The Dry Forest is commonly degraded, often very severely, by fire. Some researchers believe it may take the dry forest 50 to 200 years to recover after a single fire. A forest that has burned once should be considered to have much lower priority for conservation than one that has not. Also, the first occurrence of fire in a Dry Forest stand almost certainly greatly increases the probability of additional fires that may lead to the conversion of the forest to *tanety* grasslands. The first fire in the Dry Forest may leave much of the canopy intact while having a severe negative impact on the biodiversity and the ecology of the forest (and therefore its conservation value).

It is not clear how accurately the IEFN maps reflect this type of degradation. The Dry Forest is almost certainly more difficult to interpret accurately from satellite imagery than the rainforest types. The dry forests are composed of a mix of evergreen and deciduous broadleaf trees whose spectral response differs greatly during the dry season (when most imagery is recorded). This natural difference in spectral response may be as great or greater than the spectral response difference between forests that have burned once or twice and forests that have not.

All should be aware that the IEFN distinctions between degraded/secondary and "primary" Dry Forests are probably not clear cut because multiple levels of degradation are found. The degraded/secondary Dry Forest type has not been considered in our priority ranking of blocks of forest in the Mahajanga Region. However, LDI regional

staff, and others, should always take into consideration the uncertainties involved in the distinction between "primary" and degraded/secondary Dry Forest types. Verification in the field should concentrate on determining whether Dry Forests stands have burned in the recent past. Stands that have burned should be considered to have low priority for conservation.

2.8.3. Methodologies of Applying Criteria for Defining Regional Priorities

2.8.3.1. Subjective Analysis Two different methodologies are being used in defining regional priorities. The first is a subjective application of all the ecosystem and block criteria combined with a strong emphasis on a critical analysis of the results of the '95 Priorities Workshop plus input from the six key researchers interviewed. This subjective analysis was performed by the author in late November and early December. It was done largely without the aid of the GIS tool for analysis of block size, shape and ecosystem mix. This is because of significant delays suffered by the PACT GIS Unit that were due to many technical problems with the *BD 500* database recently received from FTM (the national geographic institute). On the other hand, the new 550 meter altitude division between Low and Montane Rainforest was done and was integrated into the analysis.

The results of the author's subjective analysis of priorities for the three regions are presented in Chapter 3.

2.8.3.2. Systematic Analysis with Strong GIS Support

Criteria to be Applied Systematically The second methodology consists of an attempt to be much more systematic and quantitative in the ranking of priorities for the three regions. It makes strong use of the ranking of ecosystems from Section 2.7. and the application of Block Criteria 1 to 3 using PACT's GIS system. Each block of natural areas in each region will be ranked systematically according to the following criteria:

1 Size of the block (Block Criteria 1);
2 Number of ecosystem types within the block (Criteria 2);
3 Ratio of circumference to area of the block (Criteria 3)
4 Priority ranking of the ecosystem type(s) included within each block (from Section 2.7;

Weighting The author recommends the following relative weighting for the above criteria:

Criteria	Description	Weight
1	Size of Block	2
2	# of Ecosystems in block	1
3	Ratio of C/A	1
4	Ecosystem priority	2

These weightings should be further debated amongst researchers and conservation professionals and adjusted as appropriate.

Advantages of the Systematic Analysis The following advantages of this systematic analysis (as opposed to the subjective ranking presented in Chapter 3) can be cited:

- The justification for the priority rankings are easily verifiable. Assumptions, hypotheses, weightings and formulae used are all made explicit.
- The assumptions and the weightings for each criteria can be modified over time and priorities recalculated with considerable ease.

Disadvantages

- Unless the results of the systematic ranking are subjectively modified, much valuable information is not exploited. This includes:
  - All of the results of the '95 Priorities Workshop;
  - All existing biodiversity survey work (much of which was subjectively integrated into the '95 Priorities Workshop;
  - Most of the input from the six key resource people interviewed on priorities in each of the three regions;
- The criteria for ranking of blocks does not necessarily lead to a definition of priorities within each block. This is especially true for the largest blocks such as the Montadia to Onibé Corridor or the Ranomafana to Andringitra to Midongy Atsimo Corridor.
- There is a danger is putting too much credence in a relatively mechanistic analysis. One should always question whether the results of the systematic analysis actually makes good sense based on biogeographic principles. Inevitably, some of the shortcoming of the methodology will only become apparent when the analysis is actually done. Some points that deserve particular attention are the following:
  - The criteria for ranking blocks were developed primarily with terrestrial ecosystems in mind. How well to they apply to the wetlands types? Rivers are an obvious exception as they are not composed of blocks. Does it make sense to apply the ratio of circumference to area criteria to lakes? Lakes with a high ratio probably have higher levels of biodiversity.
  - The very idea of a block must be examined closely for very long, thin blocks or corridors. The ultimate example in the three regions is the Ranomafana to Midongy Atsimo Corridor. Does it make sense to treat this approximately 300 km long strip as a single block? South of Andringitra, the corridor alternates between Low Altitude and Montane Rainforest types.

- The systematic analysis of blocks by region does not place them into a national context. Even a visual analysis of the national IEFN Map can be very effective in analyzing the blocks on natural areas within each region within the national context.

It is important that the results of the systematic analysis be conditioned with the types of more subjective analysis indicated above. Much of this analysis is presented in Chapter 3.

To complete the definition of regional priorities for biodiversity conservation, a small group of key resource people will visit each LDI regional office in the first half of January to present, discuss and debate the results of the systematic analysis and that of the author's more subjective analysis. The group may include representatives of LDI Tana office, PACT'S GIS Unit and USAID. Most of the principal aspects of the analysis have been discussed and debated with the regional staff during site visits in October and November. The regional staff has had most of the results of the author's subjective analysis presented in Chapter 3 since early December. The results of the systematic analysis will be a valuable addition in finalizing the definition of priorities and in finalizing the choice of LDI'' Strategic Intervention Zones.

2.8.3.3. Broader Perspective on LDI's Methodology for Regional Priority Ranking

The main difficulty that one is confronted with in defining biodiversity conservation priorities at the block level is not the definition of meaningful criteria, but the lack of appropriate data that allows one to apply the criteria. The 1995 Priorities Workshop had no criteria that could be applied systematically by block. This was due to lack of survey data collected in a systematic manner, to limitations of the ecosystem/forest cover maps available at the time and due to the much more limited development of GIS capabilities in Madagascar at that time.

LDI's systematic ranking of blocks in each region is based on bio-geographic principles and on the IEFN map and GIS capabilities that have been developed since 1995. Criteria 1, 2, 3 and 4 can now be applied systematically to all blocks in each of LDI's three regions.

Madagascar is in a unique position to apply this methodology developed by LDI. This priorities ranking methodology has potential use well beyond the three regions where LDI is working. AGERAS should closely assess the results of the priority ranking in LDI's three regions for potential application to other regions where AGERAS is working. Furthermore, ONE plans to undertake the preparation of a Madagascar's National Biodiversity Strategy and Action Plan (BSAP) during calendar year 1999. They should also closely review this methodology for application at the national level.

3. Subjective Ranking of Priorities for Each Region

3.1. Conservation Priorities for the Fianarantsoa Region

Ranking System To be consistent with the precedent established by the Priorities Workshop, the same four priority levels of biological importance are used as follows:

Exceptional importance
Very Important
Important
Moderate importance

Overview of the ecosystems in the region. The region of Fianarantsoa with its ecosystems is presented in Map 1. The most striking feature is the nearly continuous corridor of rainforest that runs from north to south. The large bulge near the center is the Andringitra Complex. The Andringitra Complex consists of an exceptional mix of ecosystems ranging from Low Altitude Rainforest to Montane Rainforest to High Montane forest and prairies. From the Andringitra Complex to the northern limit of the region, the corridor is composed almost exclusively of Montane Rainforest, nearly all of it over 800 meters elevation. From the Andringitra Complex to the Ranomafana National Park centered 40 km NE of Fianarantsoa, the corridor forms an elongated rectangle approximately 11 km wide. North of Ranomafana the corridor is badly fragmented for 40 km culminating in a 35 km wide block of Mid-Altitude Rainforest just east of Ambositra.

From Andringitra to Midongy Atsimo to the south, the corridor becomes a mosaic of Montane and Low Altitude Rainforests of increasingly irregular shape. At the level of Midongy Atsimo, the corridor ends in an irregular mix of partially fragmented Low and Montane Rainforests.

To the east of the corridor, there are isolated fragments of Littoral Forests, Low Altitude Rainforests and Montane Rainforests. None of them are large. In the extreme SW of the region lie some Montane Rainforests that are transitional to the southern semi-arid ecosystems. In the extreme west of the region are found the Woodlands that have elements of Dry Forest mixed in.

Conservation Priorities within the Corridor

Symbols in parenthesis following site names are the symbols used on the documents from the 1995 Priorities Workshop for sites on the Integrated Map: Biological Importance.

Andringitra Complex (SE-11) The 1995 Workshop identified four sites in the Ranomafana Province as having Exceptional biological importance (their highest ranking). The first is the Andringitra complex. The Workshop gave this site the highest "A" rating for species diversity, endemism and for habitat diversity. One of the first

systematic, multi-disciplinary biodiversity inventories in Madagascar was conducted in Andringitra in 1993 with the results published in 1996. Even though this survey did not include the Low Altitude Rainforest on the east side of the complex, it strongly reinforced the Exceptional Importance ranking accorded by the Workshop. Over half of all the known animals of Madagascar are found in Andringitra.

Much of the diversity is certainly due to the exceptional range of elevations within the complex. Furthermore, to the southeast and the northeast, it is contiguous to some of the largest areas of Low Altitude Rainforest south of Masoala. It has exceptional species richness and it deserves **Exceptional** priority status for conservation. (The IEFN maps do not follow the 800 cutoff indicated by their legend for the Andringitra Complex nor does it for the "corridor" south of Andringitra.

Ranomafana (E-19a) The Ranomafana National Park is the only other well-surveyed, heavily researched section of the corridor. It is the only other site that can best be compared with Andringitra based on survey results and the criteria of endemism and species diversity. As part of site E-19a it was given Very Important priority status for biological importance, one step down from that of Andringitra. Species diversity, endemism and habitat diversity are all ranked "B". The corridor is partially split within the Park along highway RN 25. There is no Low Altitude Rainforest at Ranomafana. The priority ranking of **Very Important** remains appropriate for Ranomafana.

The rest of E-19a extends north of the Park almost to the level of Ambositra. Its rating of Very Important must be questioned in light of the fact that the corridor north of the Park is badly fragmented. A **Moderate** rating is more appropriate.

Due east of Ambositra is a 35 km wide block of Montane Rainforest. No survey information on its biodiversity is known, but, by its size and relatively low ratio of circumference to area, it deserves a **High** importance priority ranking.

Andringitra/Ranomafana Corridor This section of the corridor is marked as Unknown biological importance on the '95 Priorities Map. In terms of survey work and data on the biodiversity of this corridor, it does remain largely unknown. By its geography and range of altitudes, one might assume that its biodiversity may be similar to that of Ranomafana. However, one of the main recommendations of the Workshop in general was the need to maintain corridors connecting key protected areas and key blocks of forests for the purpose of maintaining gene flows and exchange of species. The Andringitra to Ranomafana Corridor is clearly deserving of **Very Important** priority for conservation. Regional planning for the conservation of this corridor is the principal focus of AGERAS. As the Andringitra Complex is of higher priority than Ranomafana, and because the size of the corridor itself is significant, one should consider conservation of the SSW end of the corridor to be of somewhat higher priority than conservation of the NNE end.

The IEFN Map shows the corridor as cut about ¾ of the way across from its west side about 14 km NNE of where it swells into the Andringitra Complex. The narrow deforested wedge corresponds to the valley of a river that enters from the west, flows south and then out the east side. This wedge appears to be the most imminent threat to the Andringitra--Ranomafana Corridor. Preventing this cut from becoming complete should be a high priority. The current status of this wedge needs to be determined.

The Andringitra to Midongy Atsimo Corridor If the recommendation of the Priorities Workshop is correct concerning the 5-600 meter break between Low Altitude and Montane Rainforest ecosystems, then the forested band to the south is not really a corridor, but rather a mosaic of these two Rainforest ecosystems. Whole sections of this band consist entirely of one ecosystem type or the other from the east to the west side. Species that are not common to these two types of rainforest would be "held prisoner" within their respective section of this strip. For species that are found in both the Low Altitude and Montane Rainforests, this forested band should still play the ecological function of a corridor. Almost the entire "corridor" south of Andringitra is considerably narrower than the corridor NNE of Andringitra, being only a few kilometers in width in some areas. It is possible that it may have become cut in one or more places since the IEFN Map was made.

While the Andringitra to Midongy Atsimo strip may not be a true corridor, it does contain the two largest blocks of Low Altitude Rainforest south of Masoala and both of them are joined on their north and south ends by Montane Rainforests. For this reason alone, this strip is deserving of **Very High** importance status for conservation with the focus being on the Low Altitude Rainforest sections of the strip.

Non-Corridor Priorities for Conservation of the Montane Rainforest

Kalambatritra sits on the western edge of the southern part of the province. It was labeled as Unknown by the Priorities Workshop and this remains very true. Nussbaum believes it is the least known protected area in the country. Recent bird surveys done by ZICOMA found that most eastern rainforest birds are present. Most researchers refer it to as a very interesting transition between the rainforest and the dry ecosystems to the west. This rather narrow strip has a high ratio of circumference to area. It may be considered to have **High** importance.

Ivakoany This bit of Montane Rainforest south of Kalambatritra is considered to be the southern limit of many species. It is also a very poorly known site. Its small size argues for **Moderate** importance.

Midongy Sud The large areas of rainforest around Midongy Sud are very poorly known but considered to be "very interesting". It is very remote from Fianarantsoa. ANGAP is in the process of creating a new protected area in this area. Midongy sits at the north end of an unbroken corridor that extends all the way to Andohahela. Our new demarcation of the rainforest at the 550 meter extends almost down to the level of

Midongy Atsimo. No Low Altitude Rainforest occurs down this far.

Proposed Conservation Priorities for the Low Altitude Rainforest

Andringitra to Midongy Atsimo Low Altitude blocks As already discussed, the two blocks of Low Altitude Rainforest blocks within this strip are recommended to have **Very High** importance based on their size. No survey data is known to exist.

Manombo (SE-10) is one of the few fragments of Low-Altitude Rainforest of any size south of Masoala, especially of those closest to the coast. It received ratings as Very High for mammals, High for birds and Very High for plants with an overall biological importance rating of Exceptional. The Manombo complex consists of a protected area and two forest reserves. Since the '95 Workshop, Manombo suffered severe damage from a cyclone. A large portion of the trees were blown down, probably increasing the risk of wildfires. A fire occurred this year. Recently, the forest reserves have also suffered from very heavy, authorized logging (Measures are underway to confront this). Loss of the forest reserves would significantly reduce the size and viability of the Manombo complex. A Finnish NGO, Dodo, is just starting a small agroforestry project at Manombo in support of its conservation.

Opinions are split amongst those interviewed as to how high a priority Manombo should be given. Its great distance from larger intact blocks of Low Altitude Forest to the north increases the chances that it has unique characteristics and biodiversity. The corridor blocks of Low Altitude Rainforest 45 and 55 km to the west and NW, respectively, are much larger and are linked to adjoining areas of Montane Rainforest. The degraded state, small size and precarious position of Manombo argue against its conservation value. We propose that it be given a priority ranking of **Important.**

Tolongoina/Ikombo The third site accorded Exceptional status is referred to as Tolongoina (SE-12) in the Priorities Workshop documents. However its location on the map corresponds to a number of very small, Low-Altitude Rainforest fragments immediately to the west of the much larger town of Ikongo and a full 35 km south of Tolongoina. This calls into doubt what site is actually being referred to. Furthermore, the site circled as Exceptional priority is not even mentioned on any of the thematic group priority maps. In conclusion, it is totally unclear what site is referred to and why the priority rating was made. Based on their size, the Tolongoina fragments probably do not rate a higher ranking than **Moderate**.

Ifanadiana (E-19b) Several fragments of Low Altitude and Montane Rainforests are found about 10 km SE of Ifanadiana. They are classed as Very High Importance by the Priorities Workshop. No distinction is made between E-19b and E-19a (centered on Ranomafana National Park). These fragments are predominantly below 550 meters and should therefore be in a different ecosystem from the corridor. However, they are probably not particularly good representative sites of the Low Altitude Rainforest because they are on the margin of its altitudinal limit. Their small size argues for a

Moderate importance ranking. Survey data may exist that may justify a higher ranking.

Other Low Altitude Rainforest Fragments of Interest When one looks at the IEFN maps for other sizable blocks of remaining Low-Altitude Rainforest between the corridor and the ocean, one finds two main blocks. The first is the Massif de Befody 45 km NE of Mananjary. This block extends for 20 km and all under 550 m altitude. A second, larger block of rainforest is found 45 km west and NW of Nosy Varika. About half of this block is over 550 m. Both blocks should be considered high priority for survey work. An **Important** conservation priority ranking is recommended for both.

Conservation Priorities for Littoral Forests

The '95 Workshop classified the entire coastal band as Very High Priority for the conservation of Littoral Forests. Very little of the band actually contains Littoral Forest remnants. The workshop participants had no good information on the geographic location and extent of the remaining forests.

None of the researchers interviewed mentioned the Littoral Forests as priority sites. The remaining remnants are reputed to be badly degraded. This type never did cover large areas. We give them a ranking of **Moderate** priority for conservation.

Conservation Priorities of the Woodlands

The Priorities Workshop accorded the Woodlands of the extreme west of the province the ranking of Exceptional Priority. They are ranked "A" for species richness, endemism and habitat diversity. This highest ranking was not supported by any of the researchers interviewed. Goodman believes that the Woodlands at Isalo are very similar to the forests just west of them at Zombitse and Vohibasia but have less species diversity than the latter. Nussbaum reports that the Woodlands south of the national highway are much more interesting that those to the north in the Park. Nicoll stated that Isalo has "a degree of endemism". Hawkins states that there are three different wooded types. The most extensive tapia woodlands that have relatively low species diversity. In addition, Dry Forest similar to those of Vohibasia and relict stands of rainforest in areas protected by canyons that serve as natural firebreaks have much greater diversity. An overall ranking of **Important** is recommended.

Forested Areas vis a vis the "Domaine Classee"

When one compares the actual forest cover of the area from the corridor to the ocean in the Province of Fianarantsoa, one is stuck by the extremely low correlation between the actual forest cover and the locations of the officially designated *domaine classée*, i.e., *les forêts classées, les reserves forestières* and *les aires protégées.* This is in striking opposition to the situation in the Moramanga Region, where the correlation is quite high.

3.2. Conservation Priorities for the Moramanga Region

Ecosystems of the Moramanga Region

The Moramanga Region is shown if Map 2. From the south, it runs from Anosibe An'Ala 55 km south of Moramanga, to just north of Lake Aloatra. In the other direction, the region runs from the Indian Ocean in the east to the western escarpment that lies 30 km west of Moramanga.

The geomorphology and the ecosystems of the Moramanga Region are arranged in a similar fashion to those of Fianarantsoa. One significant difference in the Moramanga Region, is that there are two escarpments, each with a corridor of Montane Rainforest. The eastern escarpment runs NNE/SSW and is covered by an exceptionally broad band of rainforest. The western escarpment has a much narrower band of rainforest, much of it only about 5 km wide. This narrow band forms a continuous 130 km corridor north of the *route nationale*. It has been severely cut in recent years on both sides of the highway. As in the Fianarantsoa Region, both escarpments are much more moist throughout the year than surrounding areas, due to the orographic uplift and cooling of the moist air moving west off of the Indian Ocean by the prevailing winds.

The broad valley that lies between the two escarpments has almost no natural forest remaining on it. towards the northern end of this valley is found Lake Aloatra with its extensive marshes and rice plains.

The most striking feature of the Moramanga Region's remaining natural ecosystems is the corridor of mostly Montane Rainforest that blankets the eastern escarpment. It is much wider than its homologue in the Fianarantsoa Region. For the first 70 km north of the *route nationale*, the corridor is about 20 to 30 km in width. It then bulges to over 40 km wide east of Didy. It continues for another 40 km before being suddenly cut, or almost completely cut, along the Onibe River on the south edge of Zahamena National Park. Because of this cut, it is not accurate to speak of the Andasibe/Montadia to Zahamena Corridor. We shall refer to the corridor north of the *route nationale* as the Montadia --Onibe Corridor. North of Zahamena, the corridor is completely cut with a several kilometer wide gap. Zahamena has become an island. Andasibe protected area at the southern end has been an island for some time. The eastern corridor is also broken along the *route nationale* and the railroad.

To the SW of the *route nationale* from Andasibe, there is a sizable block of Montane Rainforest to the SW. This block is nearly cut along the road that runs between Moramanga and Anosibe An'Ala. There is anther break 15 km west of Anosibe An'Ala. This makes four breaks in the corridor from the southern to the northern limits of LDI's Moramanga Region.

Proposed Conservation Priorities within the Escarpment Corridors

Mondtadia to Onibe Corridor The Priorities Workshop accorded this area **Very Important** biological importance status and we feel that this ranking remains appropriate. However, most of the corridor, however, is largely unsurveyed. A rapid biodiversity assessment is underway under the lead of CI, and preliminary results may be available early in 1999. The IEFN Map does not indicate any near-term threats that would cut the corridor into two or more sections. The width of this corridor is quite remarkable. The corridor is very strongly dominated by the Montane Rainforest ecosystem. At least two peaks within the corridor rise to heights of 1550 and 1470 meters, respectively. Any areas rising over 1200 meters should be given special consideration – PACT's GIS Unit will identify such areas.

In general there is very little remaining Low Altitude Rainforest remaining within the Montadia to Onibe Corridor. The most important occurs 45 km due west of Toamasina. It is roughly comparable in size to the Betampona protected area, but it is solidly attached one of the easternmost tips of the corridor. This makes this part of the corridor of relatively higher conservation priority. There are bits of Low Altitude Rainforest tenuously attached to the corridor about 70 km SW of Toamasina, but their connections are so precarious that they lend little additional importance to this part of the corridor.

One of the largest marshes in the rainforest is the Torotorofotsy marsh near Montadia. Conservation of the corridor around the marsh should receive special attention.

Zahamena is a large island of Montane Rainforest with a moderate ratio of circumference to area. It has the highest concentration of species of primates of any forest in the world. It was ranked as **Very Important** by the Priorities Workshop and this ranking remains valid.

Montane Rainforest SE and S of Moramanga This 55 km long block has a NE to SW orientation. It has no Low Altitude Rainforest and is relatively narrow in the center. It has a moderately high circumference to area ratio. It is said to have high diversity of reptiles and amphibians. We agree with the **Important** conservation status given to it by the Priorities Workshop.

Western Escarpment The western escarpment is covered with Montane Rainforest. This narrow 130 km long strip appears to have a high circumference to area ratio and is in danger of being cut at several points. It does not appear to be significantly different in its biodiversity from the eastern escarpment and we agree with the **Moderate** importance given by the Priorities Workshop.

Low Altitude Rainforests

General There are much fewer remaining blocks of Low Altitude Rainforest in the Moramanga Region than in the Fianarantsoa Region, and none of them are of any

appreciable size. One could assume that they probably resemble the large blocks of Low Altitude Rainforests on Masoala more closely than the much more distant Fianarantsoa fragments.

Betampona The largest single block appears to be Betampona protected area NE of Toamasina. It is not that large. Betampona is very compact with a low circumference to area ratio. It is completely isolated and is on the verge of losing one of its lemur species. It was accorded Very Important status by the Priorities Workshop. We propose **Important** status. The stands 45 km west of Toamasina already described are contiguous to the Montane Rainforest corridor, are of approximately the same size as Betampona and would be classified as **Very Important** for these reasons.

Brickaville The two Small blocks 10 km west of Brickaville should have **Moderate** ranking.

Littoral Forests

General The Moramanga Region contains the largest remaining blocks of Littoral Forests. Their ranking here is primarily based on their size. Tampolo has recently been surveyed, but survey data for comparing Tampolo with the other blocks does not seem to be available.

SSE of Toamasina The largest remaining blocks of Littoral Forests are found within 53 km SSE of Toamasina. They are said to have been degraded by charcoal cutters. We propose **Important** status.

Mahavelona The next largest are found at Mahavelona 40 km south of Fenoarivo. They are also given **Important** status.

Tampolo A smaller stand of Littoral Forest is found 10 km NNE of Fenoarivo. We have ranked it **Moderate.**

Marshes and Lakes

Lac Aloatra and Its Marshes Opinions vary on the biological importance of Lac Aloatra. Everyone agrees that the lake and the marsh are badly degraded. The lake has suffered from severe sedimentation and has lost much of its biodiversity. The marshes have suffered from drainage, burning and various types of exploitation. However, wetlands in general in Madagascar are some of the most endangered ecosystems. Even though badly degraded, Lac Aloatra and its marshes are considered to be extremely important for waterfowl and other birds. In addition the marshes are the only home to a sub-species of lemur. We have reconfirmed the **Important** ranking given by the Priorities Workshop for the lake and its marshes.

Torotorofotsy Marsh has been proposed for protected area status by ANGAP. At least once species of endemic frog has been found here and no where else. Torotorofotsy is much smaller than the Lac Aloatra marshes but is in much better condition. It can be considered **Important**.

East coast marshes Smaller areas of marsh occur along the east coast. Many are being heavily invaded by "niaouli", a small Australian tree.

3.3. Conservation Priorities for the Mahajanga Region

Overview of the Ecosystems of the Region

The Mahajanga region covered by LDI is shown in Map 3. It covers all of the province NE of the Betsiboka. The maximum distance from Mahajanga to the furthest point west of Bealanana is 360 km.

The review of potential conservation priorities did include some analysis of the area on the SW side of the Betsiboka within 200 km of Mahajanga. Nothing exceptional enough to warrant the greatly enhanced logistical complications of working on the left bank was identified.

One of the most striking aspects of the Mahajanga Region is how little is known about the biodiversity of the area. Almost every researcher interviewed stated that they know very little about the region. Nearly all were surprised by the locations and extent of Dry Forest indicated on the IEFN Map.

Dry Forest. The types and distribution of the natural ecosystems of the Mahajanga region are very, very different from those of the other two regions. The Dry Forest is the only natural ecosystem that is widespread over the Mahajanga Province northeast of the Betsiboka. Its distribution is geographically dispersed over the region in a much more homogeneous, but broken, fashion than the forested ecosystems in the other two regions. The distribution of the dry forest is related to the geomorphology of the Dry Forest Area which is much more homogeneous with low elevations prevailing over large areas of relatively gentle relief.

Rainforest The entire western and northern boundaries of the province from 90 km south of Mandritsara to the Manongarivo Massif south of Ambanja follow closely the western limits of the Mid and Low Altitude Rainforests. Relatively little of it is included in the Province of Mahajanga and most of it is of very difficult access. Most of the pressures on these rainforests come from outside the province from the eastern and northern sides.

Priorities Identified by the 1995 Workshop

Confusion over Mahajamba/Loza The Results of the 1995 Priorities Workshop are of very little help to LDI in identifying conservation priorities for the Mahajanga region. This is much more true for Mahajanga than the other two regions. The site marked Mahajamba – Loza Estuary (0-15) is classified as having Exceptional importance. The area circled on the Integrated Map of Biological Priorities is a mix of two completely different ecosystems. Most of the area circled is unforested or degraded rainfed uplands with severely fragmented Dry Forest remnants. The rest of the area covers two bay ecosystems with mangrove estuaries.

In Table 7 of the Primate Report Special Issue 48-1, the site is described as "Mahajamba, Andranoboka, Estuary of the Loza River (defined mainly by Paleontology)". This indicates that it is the bay ecosystems that are of exceptional priority. However, Loza Estuary is not even included in the area circled. The parenthesis "defined mainly by Paleontology" would indicate that its priority rating is not based on its present day biological importance.

None of the researchers interviewed consider the mangroves/bays to be of particular biological importance, except for their importance for birdlife. Most of the species of the mangrove estuaries are reportedly not endemic to Madagascar. Furthermore, only one of the thematic groups of the Priorities Workshop gave this area any mention at all. This was the birds groups which gave it the lowest of its three priority classes. The aquatic estuaries group does give Loza estuary an exceptional ranking, but Loza is not included in the area circled. The Aquatic group makes no mention of Mahajamba Bay/estuary. One finds no justification in the thematic group priorities for according the Exceptional Importance status on the integrated biological priorities map. We can make no sense of the Workshop's ranking of this site.

Dry Forest Priorities. The Ankarafantsika complex is in the Dry Forest and it is the one site in the region that the Workshop accorded the status of Very Important. However, it is also the only section of the Dry Forest in the region where any significant biodiversity inventory/survey work has been done. The sample size of one cannot be considered significant. Ankarafantsika is certainly significant because of its size and because of its "classified" status, but there does not seem to be any basis for comparing its biological importance with other Dry Forests in the region based on the classic criteria of species richness or endemism. We do not know if Ankarafantsika should be considered to have a higher or lower biological importance than other Dry Forest sites in the region.

One of the remarkable aspects of the '95 Priorities Map is that there is no mention whatsoever of the much larger band of large and small Dry Forest fragments that appears on the IEFN map. The Dry Forests covers at least half of the roughly 50 km wide band that stretches for150 km from Mahajamba Bay to the east. With slight exceptions, these forests are not even marked as unknown on the '95 Priorities map. The largest block is

centered 70 km due east of Boriziny (Port Berger) and is larger than the Ankarafantsika complex. To confirm the accuracy of the IEFN map, the author and two of the LDI Mahajanga staff made a low altitude overflight (about 300 m above the ground) over nearly the entire length of this band of forest. About two rolls of film were taken along this transect. The overflight confirmed that the IEFN map is largely accurate in the location and extent of this band of Dry Forest.

Rainforests The Priorities Workshop recognized the Low and Montane Rainforests (N-11 or Maromandia and N-8 or Sud-Tsaratanana-Sandrakota respectively) on the north central edge of the region as Important (their third highest category). They lie approximately 80 km NE of Antsohihy. The IEFN map shows that most of the Montane Rainforests on the eastern side are badly fragmented. The Maromandia is much larger and represents part of the westernmost extension of the Low Altitude Rainforest in Madagascar. Much of it is marked on the IEFN map as being degraded, but the accuracy of this classification is unknown. A site titled Maromandia was given an Exceptional Importance rating by the mammals working group, but the area circled on their priorities map covers the largely unforested area around the town of Maromandia. Both of N-11 and N-8 sites appear to be of difficult access. The Maromandia site seems to deserve its ranking of **Important** but the Sud-Tsaratanana seems too highly fragmented to receive special mention.

Proposed Priorities for the Dry Forest

In the absence of survey data, one can assess potential biological priorities based on size, fragmentation and geographical considerations. Based on the size and shapes of the blocks of Dry Forest, we propose the following decreasing order of priorities:

- **Androna** The largest block is centered 70 km east of Boriziny on the *Bas Plateau de l'Androna*;
- Second is the **Ankarafantsika** Complex (the protected area and classified forest);
- Third is the somewhat smaller block of forest directly west of **Boriziny**;
- Fourth is the block centered 30 km SE of Antsohihy. It includes the **Bora** protected area and a forest reserve.

Bora complex The Bora block seems to be undergoing very rapid degradation. The Bora reserve has already suffered repeated forest fires. Although our October overflight only passed along the western margin of this block, our impression is that nearly all of the remaining forest lands north of the Sofia River are undergoing very rapid, severe degradation caused by repeated forest fires. This complex block has a high circumference to area ratio. A ranking of **Moderate** importance is recommended for the Bora block.

The **Boriziny block** is on the northern extension of the same low, east-facing escarpment that Ankarafantsika is situated on. The eastern 2/3 of this block is quite compact with relatively few deforested inclusions within it and a low circumference to area ratio. This

should make the feasibility for conservation more probable. No surveys are known to have been done. There is a community-based forest management initiative that has been started here by ODAI. This block enjoys relatively easy access. A ranking of **Important** is recommended for this block.

Ankarafantsika complex As the second largest block of Dry Forest and a site confirmed biological importance on the national level, the '95 Workshop ranking of **Very Important** seems to be also appropriate at the regional level. This must be conditioned, somewhat however, by the unquantified level of degradation that this complex has suffered in recent years from the frequent occurrence of forest fires. The current fire season may be the worst one yet and its impact needs to be assessed.

Androna The total amount of Dry Forest that is still linked together on the IEFN map is considerably larger than that of the Ankarafantsika complex. This large block, however, has a highly complex, deeply cut perimeter with a considerable number of non-forested inclusions within it. This could render its conservation much more difficult. Very little of this block has been designated as *domaine classée*. The very existence of this large block of Dry Forest came as a considerable surprise to all of the researchers interviewed. This block is not mentioned on the "95 Priorities map, and none of the researchers interviewed know anything about its biodiversity. This forest does not stand out well at all on the DEF/CRNE/CI/FTM map done from the 1970's Landsat imagery. On the October overflight, it appeared that a lot of the Dry Forest stands in the Androna complex are deciduous. This probably makes their interpretation relatively difficult on satellite imagery taken after leaf fall.

The Androna complex is of very broken, hilly geomorphology that is considerably different from that of Ankarafantsika. The geomorphology reflects the different type of geological formation on which it developed. One may speculate that the biodiversity of Androna would be considerably different from that of Ankarafantsika or Boriziny for these reasons.

The biological importance of the Androna complex is tentatively ranked as **Exceptional** importance. It should be a strong candidate for a rapid biodiversity survey work to assess its actual importance.

Corridors/Bongalava. None of these large blocks of Dry Forest in the Mahajanga Region are connected by corridors. The Bongalava corridor exists for most of the distance between Ankarafantsika and the Boriziny block, but the IEFN map indicates that it is already cut at one area 40 km SSW of Boriziny. If it is, indeed, already cut, its importance for conservation becomes much lower. The potential for restoring natural forest cover in an established gap appears to be highly problematic in the Dry Forest.

Proposed Priorities for the Mangroves/Estuaries

The Mahajanga region has large areas of mangroves and estuaries. On the IEFN map, the Mahajamba Bay mangrove stands are the largest in Madagascar. The delta of the Betsiboka just SSE of Mahajanga and the Loza Estuary between Antsohihy and Analalava also have extensive stands of mangroves. The only two mangrove/estuary sites that were mentioned in the '95 Priorities Workshop are Mahajamba and Loza Estuary. The confusion over this ranking is already discussed three pages earlier.

As mentioned earlier, except for their birdlife, the biodiversity of the mangroves/estuaries does not seem to be particularly special in terms of the main criteria for biological importance, especially in terms of endemism. However, the ecological role of the mangroves/estuaries as the breeding and reproductive sites for a wide range of marine fauna is a critical one. These include many species of prime economic importance. This makes conservation of the mangroves and estuaries of very high economic importance. The Mahajamba and Loza mangroves are given a proposed biological importance level of **Important**.

The October overflight went directly over the heart of the Mahajamba mangroves. They appear to be in excellent condition. From 300 meters, they would appear to be some of the most unthreatened, least degraded stands seen during the author's field trips in the three regions.